Space Weather Technical Forecast

Issued on Monday, 13 May 2024 at 01:10 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1-G2 (Minor-Moderate) Geomagnetic storms. Decreasing Chance of X-class flares (R3 - Strong radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is High with X-ray activity showing frequent M-class flare activity, peaking with an X1.0 flare from the large region in the southwest at 12/1626 UTC. There are thirteen sunspot groups on the disc, with a new region in the southeast. The sunspot region in the southwest is the largest and most magnetically complex region. There has been consolidation of the broader penumbral area and notable relative movement between the various mixed polarity spots, presenting large magnetic shear and further potential for large flares.
AR3664 is by far the largest and most complex region on the disc, which has been the case over recent days. It continues to present as a Zurich Fkc with Mt Wilson Beta-Gamma-Delta classification. Although growth of the region has slowed, there has been consolidation of the broader penumbral area and notable relative movement between the various mixed polarity spots, presenting large magnetic shear and further potential for strong flares. There are numerous Mt Wilson deltas present. The remaining regions on the visible disc are smaller and more magnetically simple. No further significant CMEs were observed to depart the sun towards Earth during the past 24 hours.

Solar Wind / Geomagnetic Activity: The solar environment has been unusually enhanced over the past 24 hours following the two CME impacts late on the 10 May. Solar winds, as observed by ACE at L1, have been mostly at very strong levels throughout the period, with a peak of 1005km/s at 12/0055 UTC, with a steady decline down to 830km/s, before a jump back up to 900km/s due to a weak CME arrival observed at 12/0855UTC at L1/ACE data. This was followed by an unsteady decline to 800 km/s. Solar wind density has been mostly near average, with a peak of 12ppcc at 12/0335 UTC. The IMF started the period at Moderate to Strong levels before a steady decline down to weak levels, although a jump back up to Moderate levels was observed at 12/0855 UTC due to a weak CME arrival. The north-south component (Bz) was at weak to moderate levels in a range +8/-6 nT. The phi angle started negative (towards the sun) before a switch to positive (away from the Sun) was observed around 12/0300 UTC.
The net result of the above solar wind measures was a Strong Storm (G3/Kp7) 12/0000-0600 UTC, with an temporary decline towards Unsettled-Active (Kp3-4) levels, but has now increased again to Moderate Storm G2/Kp6 levels.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) observed at GOES18 declined and is now below the S1 threshold.
High energy electron flux (greater than 2MeV) observed at GOES16 was at normal background to moderate levels. The associated 24-hour fluence was well below the Active threshold. Observed fluence at 12/2100 UTC was 5.43e6 integrated pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Isolated X-class flares are probable in the coming days with further M-class flares expected, primarily from AR3664.

Solar Wind / Geomagnetic Activity: A CME from a X5.8 flare that departed the sun from the large region in the southwest at 11/0115 UTC is anticipated to impact the Earth at the start of Day 1 (13 May). A further CME associated with the M8.8 flare from the same region at 11/1526 UTC, may arrive later on Day 1 or early on Day 2 (13/14 May. Geomagnetic activity will probably be near Unsettled-Active (Kp3-4) levels. If and when the CMEs arrive activity is likely to become G1-G2 (Minor-Moderate) with an isolated iG3 (Strong storm) interval possible. Activity is expected to wane through Days 3 and 4 (15 and 16 May), however confidence at the end of the period is low and the forecast may change should further large Earth-directed CMEs occur.

Energetic Particles / Solar Radiation: Solar radiation levels are declining and below S1/Minor Storm levels and probably remaining at similar levels in the absence of any further significant flaring from the large sunspot in the southwest disc. The region is, however, moving into a more favourable location for proton response in the coming days..
High energy electron flux is forecast to be at normal background levels to start but are predicted to rise markedly in coming days depending on the degree of geomagnetic and CME activity, with moderate to high levels likely to be attained by Day 3 (15 May). The associated fluence will probably exceed the Active (1e8 integrated pfu) threshold by the same time.

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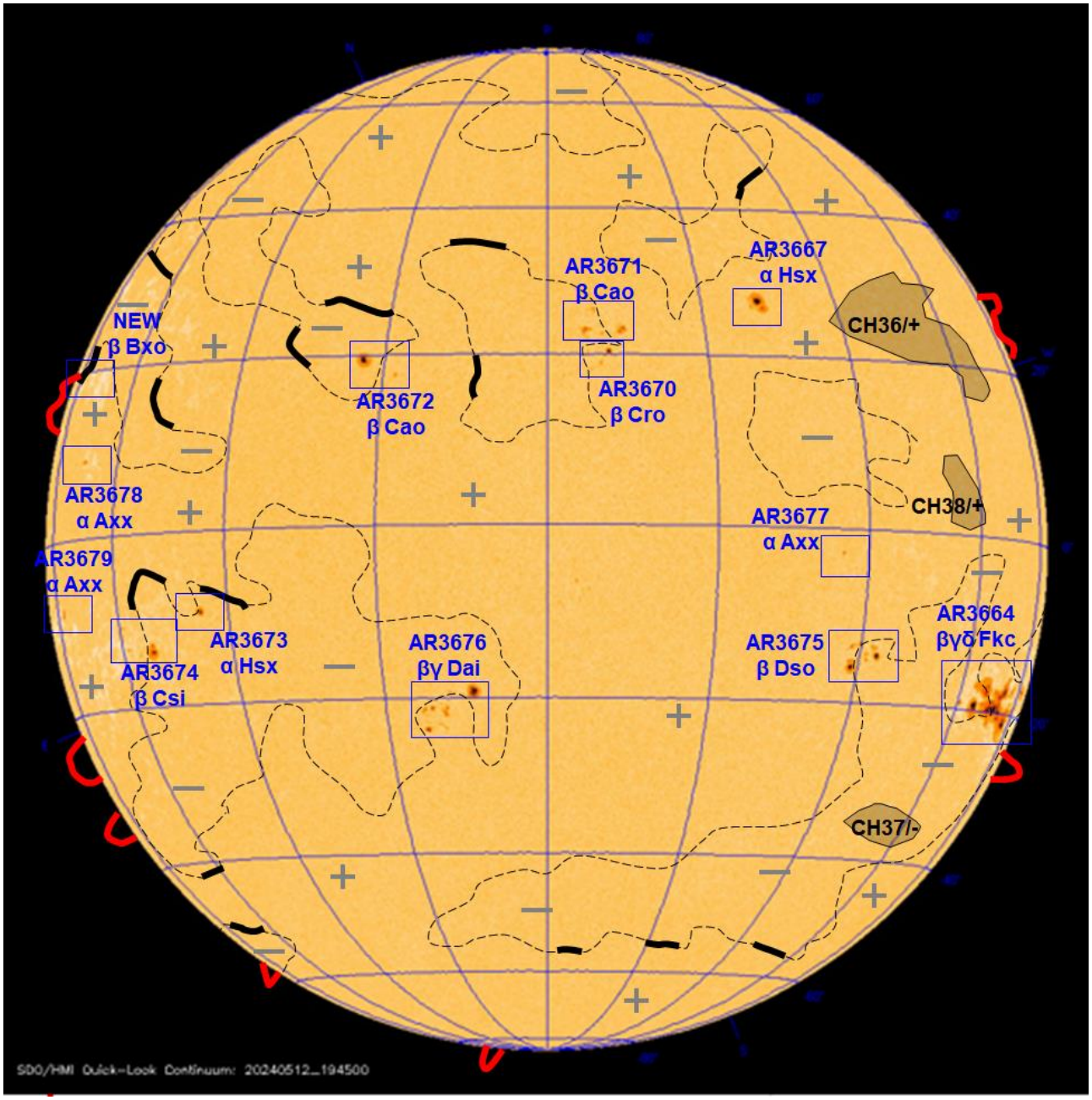
Figure 1. Solar Analysis Valid 2000 UTC, 12 May 2024.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME from a X5.8 flare that departed the sun from the large region in the southwest at 11/0115 UTC is anticipated to impact the Earth at the start of Day 1 (13 May). A further CME associated with the M8.8 flare from the same region at 11/1526 UTC, may arrive later on Day 1 or early on Day 2 (13/14 May. Geomagnetic activity will probably be near Unsettled-Active (Kp3-4) levels. If and when the CMEs arrive activity is likely to become G1-G2 (Minor-Moderate) with an isolated iG3 (Strong storm) interval possible. Activity is expected to wane through Days 3 and 4 (15 and 16 May), however confidence at the end of the period is low and the forecast may change should further large Earth-directed CMEs occur.

Other drivers of geomagnetism from coronal hole enhancements are expected to be masked and pale in comparison to the ongoing CME effects. A minor coronal hole enhancement may be contributing to enhanced geomagnetic activity observed at Earth, although this (CH38/+) may well have opened too late for any arising fast wind to intersect the Earth, which would delay the inbound fast wind to the larger and more intense CH36/+. Small CH37/- in the southern hemisphere may also connect with Earth at the start of this guidance period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	90	50	10	10
Strong	G3	Yes	50	20	1	1
Severe	G4	No	5	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0443	Partial	AR3664	SW	1250 km/s	12/1800UTC	Bulk of CME to the West

Figure 2: MOSWOC Enlil and ensemble – shows possible CME arrivals during 12-13 May.

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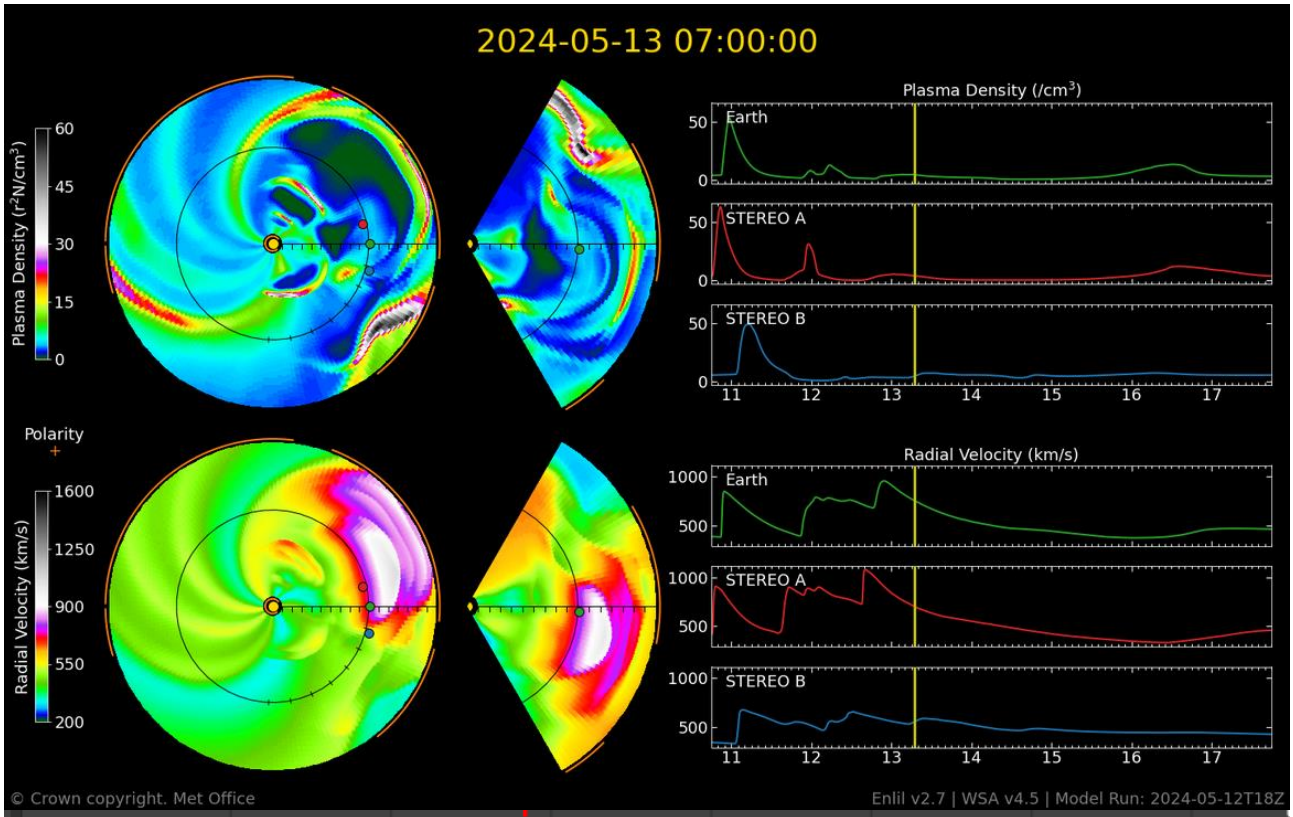

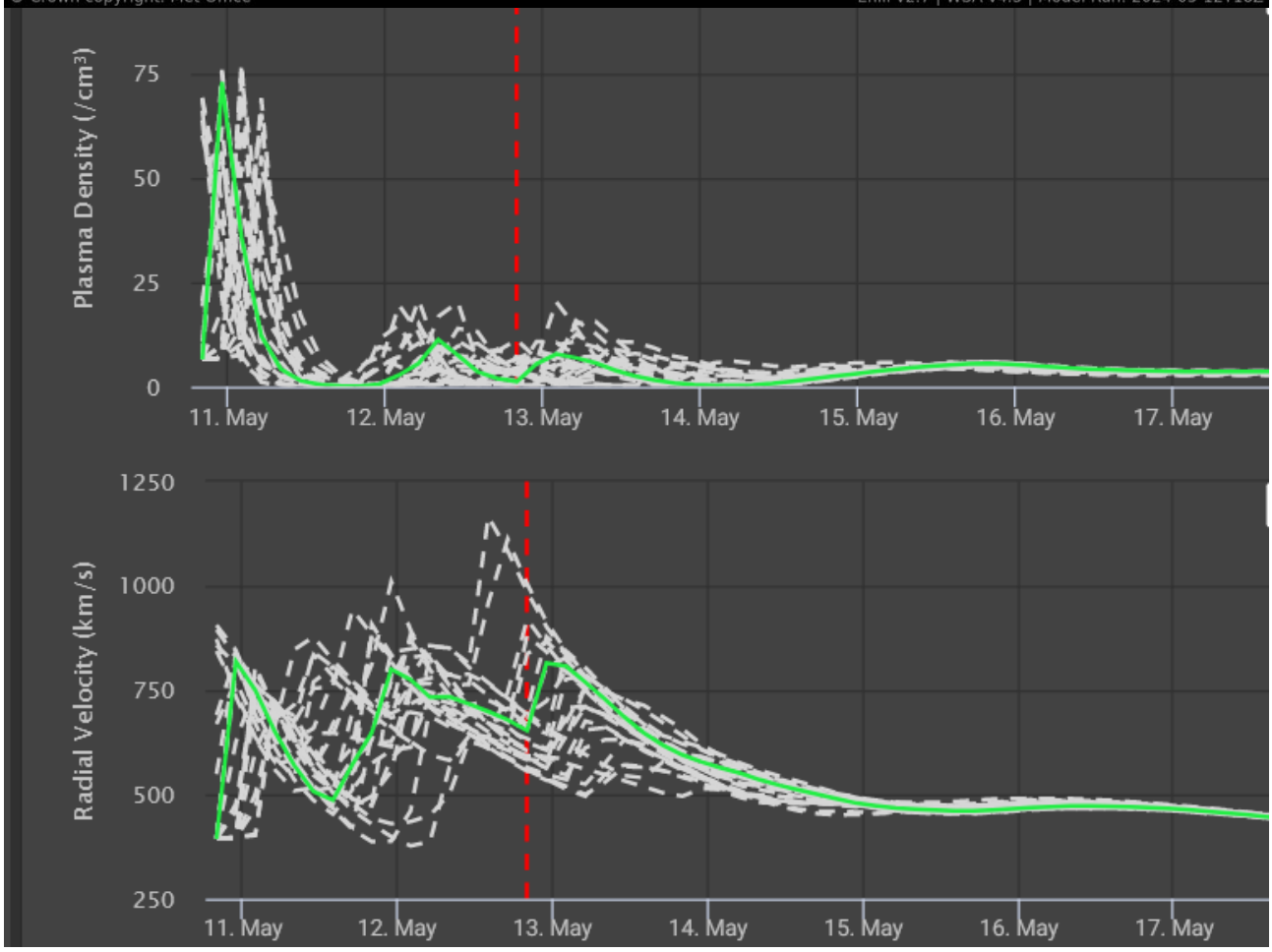

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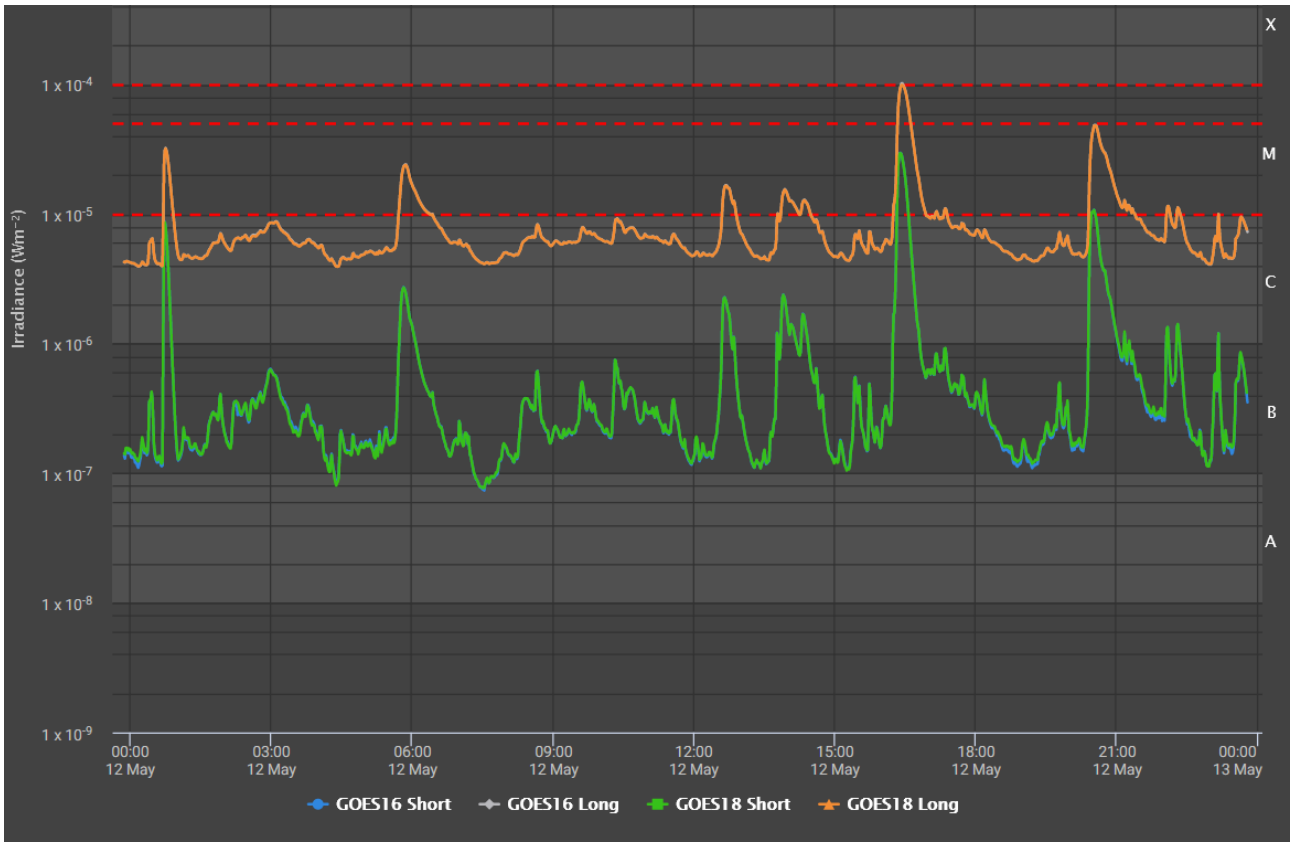
Radio Blackouts - X-Ray Flares:
Solar activity for much of the past UTC week has been dominated by the large and complex region AR3664 and this will persist on the visible disc until the end of Day 1 (13 May), when it will rotate across the southwestern limb. Further sunspot regions are rotating across the eastern horizon, but no significant active region is anticipated for the time being. There is continuing decrease in the risk of R3 as AR3663 rotates across to the far side however the risk remains for much of the guidance period. Isolated X-class flares are probable in the coming days with further M-class flares expected, primarily from AR3664.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	60	40	20
Very Active	R3 to R5 X Class	Yes	60	40	20	1

Figure 3: GOES X-Ray flux trace displaying one X-class flare at 16:26 UTC.



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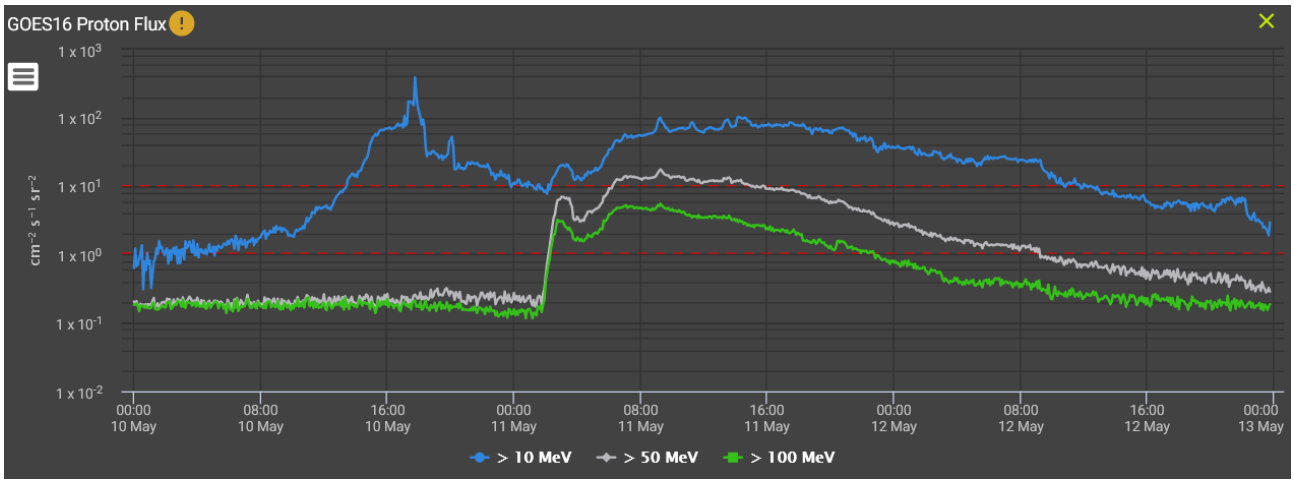
Solar Radiation Storms - (High Energy Protons):
High energy proton flux (greater than 10MeV) observed at GOES18 having increased in response to active flaring of AR3664 and the arrival of multiple CMEs on 10 May, is now declining steadily and is below the S1/Minor Storm level. AR3664 will continue to present a risk as it transits to a favourable location for proton response in the coming days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	30	30	20	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES16 Proton Flux over the past 3-days –declining trend following the recent strong flares from AR3664 in the southwest.



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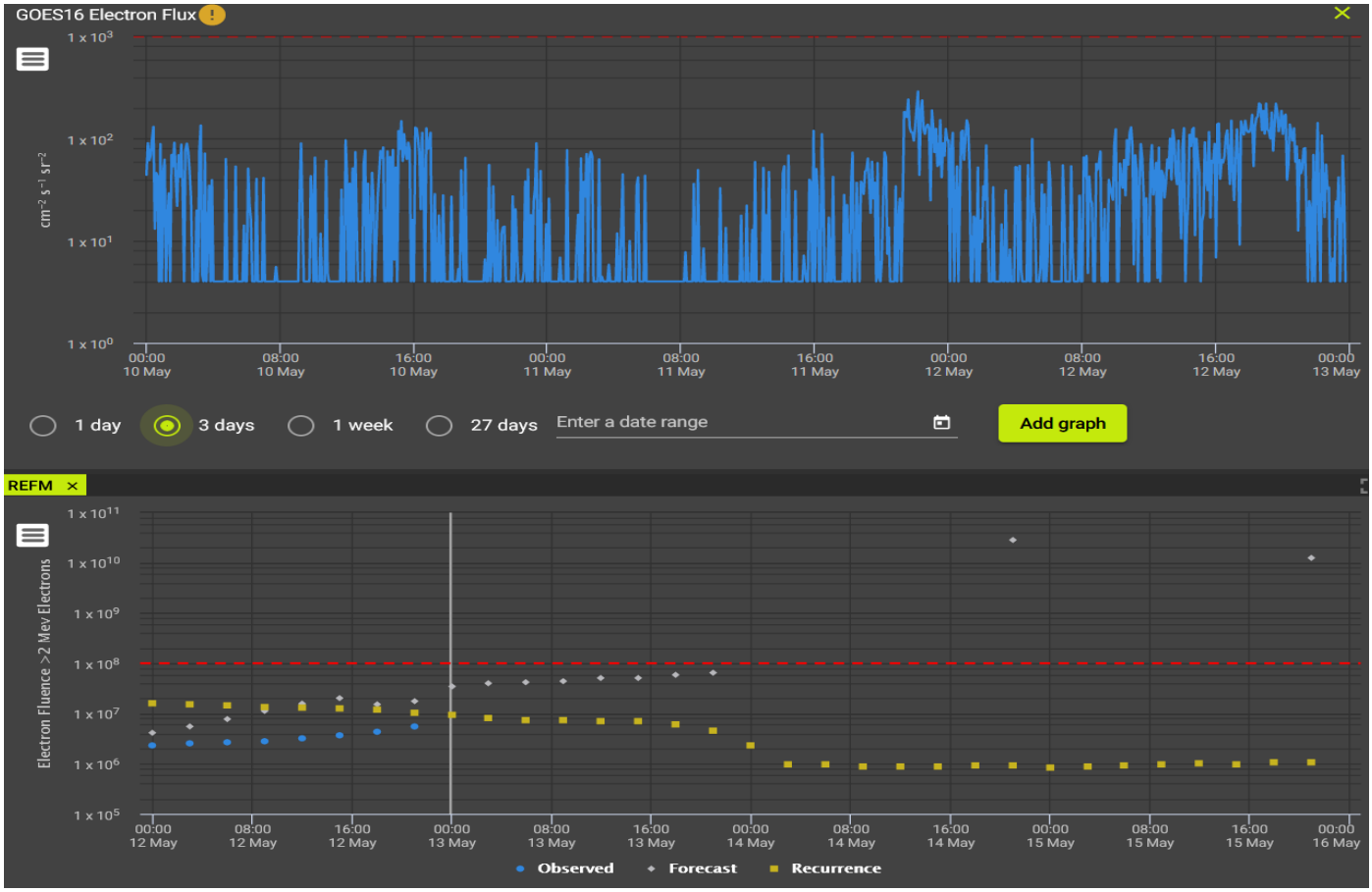
High Energy Electrons Event (≥ 2MeV):
High energy electron flux is forecast to be at normal background levels to start but are predicted to rise markedly in coming days depending on the degree of geomagnetic and CME activity, with moderate to high levels likely to be attained by Day 3 (15 May) as significant charging of the Van-Allen belts continues apace.

The associated fluence will probably exceed the Active (1e8 integrated pfu) threshold by the same time. The Met Office REFM output is considered to offer useful guidance in the coming days with a sharp uptick indicated through the guidance period but the very high levels offered in current guidance are not likely to be attained.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ 1x10^8**	No	1	30	50	70
Very Active	**≥ 2 MeV ≥ 1x10^9**	No	1	1	10	20

Figure 5: High energy electron flux at GEO and MOSWOC REFM electron fluence.



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